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VERTICAL CVD REACTOR

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[There are no amendments to this patent.]

Claims

1. A vertical CVD reactor characterized in that a cooling tube is provided at the center of a vertically placed reaction tube along its axial direction, an annular wafer supporting body is provided so as to surround said cooling tube, a heating means is provided on the outer side of said cooling tube, and the inner circumferential surface of said supporting body that faces the aforementioned cooling tube is used as a wafer mounting surface.

2. The vertical CVD reactor described under Claim 1, characterized in that heating by the aforementioned heating means is realized by means of resistance heating.

3. The vertical CVD reactor described under Claim 1, characterized in that the aforementioned cooling tube runs through a base on which the reaction tube is placed, the top part of said cooling tube being positioned in an inner upper area of the reaction tube.

4. The vertical CVD reactor described under Claim 1, characterized in that the aforementioned cooling tube runs through the upper part of the reaction tube, and the bottom part of said cooling tube is placed in an inner lower area of the reaction tube.

5. The vertical CVD reactor described under Claim 1, characterized in that the aforementioned cooling tube runs through the reaction tube in the vertical direction.

6. The vertical CVD reactor described under Claim 1, characterized in that an upper cooling tube is provided at the top of the reaction tube.

Detailed explanation of the invention

Technical field

The present invention pertains to a vertical CVD reactor, wherein a reaction gas is introduced into a reaction tube in order to form a film on a wafer mounted on a supporting body.

Prior art and problems thereof

In the case of a recent method for depositing an epitaxial film on a composite semiconductor, a metallic metal (MO) gas, is used whereby a good quality film is deposited using a CVD (Chemical Vapor Deposition) method and is used for a laser, a high-speed memory, and an FET, for example.

Because an MO gas is immediately disintegrated by heat, it is desirable to heat only the wafer mounted on a wafer supporting body, such as a susceptor or a board. From this viewpoint, what is a so-called cold wall method, which involves induction heating utilizing an RF (Radio Frequency) coil or heating by means of an infrared lamp, is widely adopted.

A heating method based on the so-called hot wall method involving resistance heating is difficult to use in reality because thermal disintegration occurs quickly especially when an MO gas is used as described above, and the reaction gas adheres to various parts inside the reaction tube, resulting in the so-called snowflake problem.

On the other hand, induction heating utilizing an RF coil has problems in that it is inferior to resistance heating in terms of temperature uniformity, and in that its power efficiency is also poorer.

Horizontal type and vertical type reaction tube structures are known involving an RF heater or a lamp depending on how the reaction tube is placed. Here, the vertical type is

advantageous in that it offers better wafer housing efficiency. Said vertical type can be further classified into an inner heating type, wherein a heater or a lamp is provided in the vertical direction of the reaction tube, an annular susceptor is placed at the center part via a quartz tube, and its outer circumferential surface is used as a wafer mounting surface, and an outer heating type, wherein a heater or a lamp is provided outside the reaction tube, and a tilted outer surface of a susceptor provided inside the reaction tube is used as a wafer mounting surface.

In the case of the aforementioned inner heating type, when the process temperature on the wafer surface is brought to 650°C or so, the heater temperature is then 1300°C or so, which poses a risk to the quartz tube provided outside the heater, so that safety cannot be assured when AsH_3 or PH_3 is used. In addition, the heater-top temperature is also high, that is, 300°C or so at the gas entrance, resulting in the possibility that the gas may disintegrate before it reaches the wafer.

On the other hand, the outer heating type has a problem that a film accumulates on the surface of the quartz to make it foggy, so that the wafer temperature is unstable.

Objective of the invention

The present invention was devised in light of the aforementioned various situations, and its objective is to improve the conventional vertical structure so as to present a vertical CVD reactor suitable for depositing a film on a wafer using an MO gas with which reactor temperature uniformity and device safety can be assured, and with which a similar level of effect to that of the cold wall method can be achieved even when an outer heating type resistance heating method is utilized while attaining good power efficiency.

Outline of the invention

In order to achieve the aforementioned objective, the present invention proposes a vertical CVD reactor in which a cooling tube is provided at the center of a vertically placed reaction tube, an annular wafer supporting body is provided so as to surround said cooling tube, a heating means in the form of a so-called outer heating type is provided outside said cooling tube, and the inner circumferential surface of the supporting body that faces the aforementioned cooling tube is used as a wafer mounting surface.

According to the aforementioned configuration, because the cooling tube is provided at the center part of the reaction tube, the reaction gas introduced from above the reaction tube can be led to the wafer reliably without disintegration in the space created at the center part before it reaches the wafer, and the wafer itself can be heated sufficiently using an outer heating type heating means via the supporting body. Thus, resistance heating can be adopted for said heating means in place of RF coil-based induction heating, so that although it is a hot wall method, a

similar effect to that of the cold wall method can be achieved. As a result, a vertical CVD reactor suitable for film formation using an MO gas is obtained.

A variety of application examples of the present invention shown in figures will be explained below.

Application examples

First, in the first application example shown in Figure 1, 10 represents a quartz reaction tube provided vertically on base 12 via gasket 11 at its base part in a detachable fashion using clamp 14; 16 represents a center cooling tube provided inside reaction tube 10 so as to run through base 12 via gasket 13 along the center axial line in the vertical direction of said reaction tube 10; 18 represents an annular wafer supporting body referred to as a susceptor or a board made of graphite so as to surround said cooling tube 16 inside reaction tube 10; 20 represents a coil heater that is wound around the outside of reaction tube 10 so as to constitute an outer heating type heating means while it is covered by heater cover 22 and connected to power supply 24 so as to transmit heat when it is heated by means of resistance heating; and 26 represents a rotary drive mechanism for rotating wafer supporting body 18 around the center axis line of reaction tube 10 and cooling tube 16.

Rotary drive mechanism 26 is configured with rotary member 30 that is fixed to the base of leg 28 of supporting body 18 while provided with engagement gear part 30a on its periphery, supporting frame 34 fixed to base 12 so as to support said rotary member 30 via bearing 32, drive gear 36 that engages with engagement gear part 30a of rotary member 30 from outside, drive shaft 38 that supports said gear 36 by one end while extending outside reaction tube 10 through base 12 via gasket 37, and external motor 42 that transmits a driving force to said shaft 38 via coupling 40.

That is, when motor 42 rotates, its turning force is transmitted to rotary member 30 via drive shaft 38 and gear 36, and wafer supporting body 18 is rotated as a result.

Water or a gas as a cooling material is introduced into aforementioned cooling tube 16 through inlet 44. Pipe 46 is inserted deep into said cooling tube 16 in order to maintain the level of the cooling material inside tube 16, and the cooling material is discharged from the top of pipe 46 through outlet 48 created at the bottom. Curved top part 16a of cooling tube 16 extends to an upper area inside reaction tube 10 in order to guide a flow of gas smoothly from reaction gas inlet 50 created at the upper center of reaction tube 10. Here, gas outlet 51 is created on base 12.

Upper cooling tube 52 for cooling the upper area inside said tube is formed at the top of reaction tube 10, and cooling water supplied into said tube 52 through inlet 54 is discharged through outlet 56. In this case, a gas may be used as the cooling material.

Wafer supporting body 18 is formed into the shape of a polygonal plane with inner circumferential surface 18 [sic; 18a] tilted with respect to cooling tube 16, and said inner circumferential surface 18 is configured to serve as a mounting surface for wafer W. On the other hand, outer circumferential surface 18b of supporting body 18 is formed into the shape of a circular plane and is placed at the smallest possible distance from the inner circumferential surface of reaction tube 10.

In the vertical CVD reactor configured in the aforementioned manner, the reaction gas, such as an MO gas, is introduced into reaction tube 10 through gas inlet 50 and is led between said cooling tube 16 and wafer mounting surface 18a of supporting body 18 while being led around top part 16a of center cooling tube 16 in order to form a prescribed film on wafer W, and the post-reaction gas is exhausted outside through gas outlet 51 when it flows further down.

Therefore, the reaction gas is cooled at center cooling tube 16 and upper cooling tube 52 before it reaches wafer W from gas inlet 50. Thus, even when outer heating type coil heater 20 utilizing resistance heating is used, the temperature increase can be restrained, so that a similar effect to that of the cold wall method can be achieved.

Furthermore, a design that does not require upper cooling tube 52 is feasible depending on how well a cooling effect can be attained using center cooling tube 16. The cooling effect is achieved mainly by center cooling tube 16, and upper cooling tube 52 supports said function.

Regarding the aforementioned wafer film formation function, rotary drive mechanism 26 is responsible for rotating supporting body 18 in order to improve the uniformity of the film formation.

Next, for the second application example of the present invention shown in Figure 2, components corresponding to those in the first application example are assigned with the same reference numbers, and only different components will be explained below.

In the second application example, center cooling tube 16 extends inwardly from the top of reaction tube 10, and bottom part 16b of cooling tube 16 runs through the center part of annular wafer supporting body 18 and reaches a lower area of reaction tube 10 close to base 12.

Cooling water or gas is introduced through the inlet at the top of pipe 46 and is discharged through the outlet created at the top of the tube 16.

In this case, inlet 50 for the reaction gas is configured with multiple pipes, which run through upper cooling tube 52, on the top of reaction tube 10 at positions offset from cooling tube 16 provided at the center portion.

Next, for the third application example of the present invention shown in Figure 3, components corresponding to those in the first and second application examples are assigned with the same reference numbers, and only different components will be explained below.

In the case of the third application example, a configuration in which center cooling tube 16 is provided at the center part of reaction tube 10 while running through it vertically is shown, wherein the bottom part runs through base 12 via gasket 13 in the same manner as in the first application example, the top part runs through the center part of cooling metal flange 60 via gasket 62, and water or a gas for cooling is passed through the inside of the tubular part constantly in one direction as indicated by arrows. Cooling metal flange 60 serves both the cooling function of upper cooling tube 52 in the aforementioned application examples and the function of a cap that closes off the top part of reaction tube 10 via gasket 63. Multiple reaction gas inlets 50 can be provided on said flange 50 [sic; 60].

Here, for upper cooling tube 52, it is also feasible to provide another cooling unit outside the top part of the reaction tube to replace the configuration of the first and second application examples in which it is formed as one body with the top part of reaction tube 10.

Figure 4 shows a modified configuration of center cooling tube 16 based on the configuration of the second application example.

Here, cooling chamber 16a is provided separately inside center cooling tube 16, wherein said cooling chamber 16[a] is formed in an annular shape along the inner wall of cooling tube 16, and its height is slightly offset upwardly with respect to wafer W mounted on supporting body 18; that is, its positional relation to wafer W in the vertical direction is offset upwardly. This is done considering the configuration wherein wafer W is placed with a tilt so that its lower part is thus placed closer to cooling tube 16 than its upper part and considering the temperature distribution in the longitudinal direction of wafer W. When said configuration is adopted, a uniform even temperature distribution can be achieved.

Furthermore, the cooling water or gas is introduced into cooling chamber 16a by pipe 46a that is inserted deeply into cooling chamber 16a, and it is discharged through pipe 46b connected to the top part of cooling chamber 16a.

Figure 5 shows a modified configuration of wafer supporting body 18, wherein protrusion 18c is formed at the top of outer circumferential surface 18b of supporting body 18 that faces reaction tube 10, that is, the side where reaction gas indicated by an arrow flows into gap 70 formed between reaction tube 10 and outer circumferential surface 18b of supporting body 18, along the entire outer circumference.

As such, gap 70 is very small, and the flow of reaction gas into gap 70 is restricted, so that the thermal transmission efficiency can be further improved.

Figure 6 and Figure 7 show split structures for supporting body 18 that simplify the mounting/removal of wafer W with respect to supporting body 18.

In the first through third application examples, the fact that clamp 14 is released and reaction tube 10 is hoisted from base 12 when mounting wafer W on supporting body 18 is the

same as that with a conventional vertical structure. However, in the present invention, because wafer W mounting surface 18a is provided inside, it is possible that mounting of said [wafer] may be difficult due also to the presence of center cooling tube 16.

Therefore, to simplify this, as shown in Figure 6, a split structure comprising part A and part B is adopted to configure wafer supporting body 18, and opening at vertical hinge part C in the direction indicated by an arrow is implemented when mounting wafer W.

In addition, as shown in Figure 7, it is also feasible to adopt a configuration in which wafer supporting body 18 is divided into multiple split parts A, B, C, D … that can be unfolded radially with respect to the base part or the center part.

Application examples and modification examples have been explained above. In the present invention, because outer circumferential surface 18b of supporting body 18 is positioned parallel to the inner circumferential surface of reaction tube 10, a larger heating area can be realized than with the conventional vertical type in which the wafer is mounted on the outer circumferential surface of the susceptor, and a heater temperature of 800°C or lower is sufficient when the wafer surface is to be heated to 650°C. As such, there is no risk of damage to the quartz reaction tube, so that a high level of stability can be attained.

In addition, because the center cooling tube can be easily heated to 1000°C or higher when it is not cooled, cleaning for defogging of the quartz and so-called board bake cleaning for removing absorbed gas can be carried out easily by taking advantage of said high temperature, which offers an additional effect.

Furthermore, although a wafer supporting body with a rotating configuration was shown in the application examples, a fixed type may be utilized also. In addition, the outer heating type heating means may be replaced with heating using an infrared ray lamp, for example.

Above the present invention has been described using application examples, but the embodiments are not limited to this.

Effect of the invention

As described above, because the present invention has a configuration in which the cooling tube is provided at the center of the reaction tube, the annular wafer supporting body is provided around it, the sufficient resistance heating type heating means is provided outside the reaction tube, and the inner circumferential surface of the supporting body facing the cooling tube is used as the wafer mounting surface, the reaction gas introduced into the reaction tube can be supplied to the wafer reliably without being disintegrated. In addition, because the wafer can be heated with outer heating type resistance heating, temperature uniformity and power efficiency as advantages of the hot wall method can be improved while solving the shortcomings of the hot wall method, and the wafer can be heated in a similar manner as with the cold wall

method, so that a vertical CVD reactor suitable particularly for wafer film formation using an MO gas can be presented.

Brief description of the figures

Figure 1, Figure 2, and Figure 3 are vertical cross-sectional views of the first, the second, and the third application examples of the vertical CVD device of the present invention, respectively. Figure 4 and Figure 5 are partially enlarged views of partially modified configurations of the present invention, respectively. Figure 6 and Figure 7 show different split structures of for the wafer supporting body, respectively.

10 Reaction tube
12 Base
16 Center cooling tube
18 Wafer supporting body
20 Coil heater
26 Rotary drive mechanism
50 Gas inlet
51 Gas outlet
52 Upper cooling tube

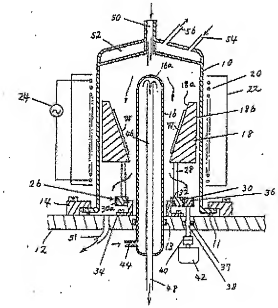

Figure 1

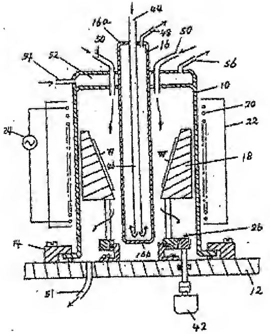

Figure 2

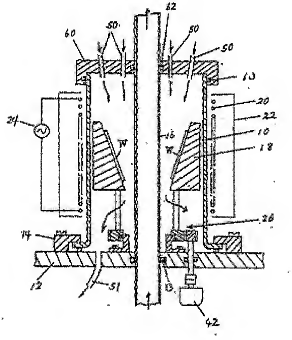

Figure 3

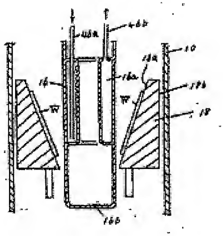

Figure 4

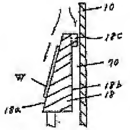

Figure 5

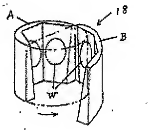

Figure 6

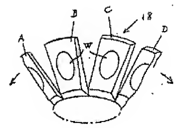

Figure 7